REMARKS

In view of the above amendments and following remarks, reconsideration and further examination are requested.

Attached hereto is a marked-up version of the pages of the substitute specification and claims to which changes have been made by the current Amendment. The attached pages are captioned ***"Version With Markings To Show Changes Made."***

By the current Amendment, claims 27 and 29-40 have been amended, claims 56-60 have been added, and claims 28 and 41-55 have been cancelled.

With regard to the amended claims, claim 27 generally corresponds to a combination of former claims 27 and 55, claim 57 generally corresponds to former claim 50 rewritten in independent form, and new claim 59 generally corresponds to former claim 51 rewritten in independent form.

On page 2 of the Office Action, the Examiner objected to the drawings for failing to show every feature of the invention specified in the claims. Specifically, the Examiner expressed that the joining member must be shown in the drawings or this feature cancelled from the claims. Accordingly, provided herewith is a proposed new drawing, i.e. Figure 19, which is a schematic cross-sectional view showing how the lower face electrode is joined to the heating radiating plate 10 via solder or conductive paste. No new matter is entered by this figure. The Examiner is requested to approve this proposed new figure, and upon allowance of this application, a formal drawing will be provided.

On page 2 of the Office Action, the Examiner also expressed that the Amendment filed August 8, 2002, is objected to under 35 U.S.C. 132 because it introduces new matter into the disclosure. Specifically, the Examiner expressed that the term "projecting electrodes" constitutes new matter. This position taken by the Examiner is respectfully traversed, since the term "projecting" was merely added to the specification to re-name the pillared or spherical electrodes. Clearly the pillared or spherical electrodes "project" from the semiconductor and heat radiating plate such that it is respectfully submitted that calling these electrodes "projecting electrodes" is proper and does not constitute e new matter.

Regardless, the phrase "projecting electrodes" has been deleting from the substitute specification and, in the claims the term --pillared-- has been substituted for the term "projecting".

By deletion of the phrase "projecting electrodes" from the substitute specification, and substitution of --pillared-- for "projecting" in the claims, the 35 U.S.C. 112, first paragraph, rejection as expressed on page 3 of the Office Action with regard to the use of the phrase "projecting electrodes" is believed to have been obviated.

With regard to the Examiner's rejection of claim 55 as containing new matter because of this claim reciting --solder and conductive paste-- while the specification recites "solder or conductive paste", this position taken by the Examiner is respectfully traversed, since page 22, lines 16-19 of the original specification recite "one of...solder...and conductive paste". This language of the original specification, and the language of claim 55, requires that the joining member comprises **one** of solder and conductive paste. Thus, claim 55 does not recite that the joining member comprises both solder and conductive paste as expressed by the Examiner, but rather that the joining member comprises **one** of solder and conductive paste, i.e. solder or conductive paste. Regardless, the claims now recite --solder or conductive paste-- in an effort to avoid any possible confusion.

With regard to the 35 U.S.C. 112, second paragraph, rejection of claims 27-55 as expressed on page 3 of the Office Action, it is respectfully submitted that the proposed new drawing obviates this rejection since this drawing shows solder or conductive paste joining the lower face electrode to the heat radiating plate.

With regard to the 35 U.S.C. 112, second paragraph, rejection of claims 31 and 38 as expressed on page 4 of the Office Action, this rejection is respectfully traversed because the term "different", while being broad, is not indefinite. Regardless, claims 31 and 38 have been amended to recite

> said second semiconductor exhibiting different characteristics relative to said first semiconductor.

This language is believed to address the Examiner's 35 U.S.C. 112, second paragraph, concerns with regard to claims 31 and 38.

As expressed above, claim 27 has been amended to incorporate thereinto the subject matter of former claim 55, and new claims 57 and 59 respectively correspond to former claims 50 and 51 rewritten in independent form. Accordingly, the Examiner's prior art rejection of claims 50, 51 and 55 will be addressed.

With regard to amended claim 27, i.e. former claim 55, it is noted that this claim was not rejected on the basis of any prior art. Accordingly, in view of the proposed drawing figure provided herewith, which addresses the Examiner's concerns with regard to claim 55, and in view of the discussion contained on pages 12-15 of the Response filed August 28, 2002, with regard to claims 27 and 55, it is respectfully submitted that none of the references relied upon by the Examiner, either taken alone or in combination, teaches or suggests a semiconductor package including a first semiconductor having an upper face electrode and lower face electrode, and

> a heat radiating plate having a surface to which is joined said lower face electrode via solder or conductive paste...with said solder or conductive face being in contact with said lower face electrode.

Thus, it is respectfully submitted that claim 27 and its dependent claims are allowable.

With regard to new claims 57 and 59, as expressed previously these claims correspond to former claims 50 and 51 rewritten in independent form. Each of claims 50 and 51 depended from former claim 41, and accordingly, each of claims 57 and 59 include the subject matter of former claim 41. Thus, each of claims 57 and 59 recite that

> leading ends of said pillared electrodes...are substantially equally spaced relative to one another from said surface of said heat radiating plate.

This limitation is not disclosed or suggested by a combination of Takahashi et al. and Hikita et al. for the reasons as expressed on page 16 of the Response filed August 28, 2002, with regard to the discussion of claims 35 and 41.

Accordingly, because no combination of Takahashi et al. and Hikita et al. would result in pillared electrodes that are substantially equally spaced relative to one another from the surface of the heat radiating plate, claims 57 and 59 are allowable. Similarly, claim 35 is believed to be patentable in its own right, since this claim includes language similar to the above quoted language of claims 57 and 59.

In supporting the rejection of claims 35 and 41, the Examiner has apparently taken the position that these claims could be read on a combination of Takahashi et al. and Hikita et al. by considering only the leading ends of electrodes 29 of Takahashi et al. while not considering the leading ends of the additional electrodes to be added in view of Hikita et al., since these additional electrodes will clearly not have leading ends that are equally spaced from a common surface relative to the leading ends of electrodes 29.

However, claims 35 and 41 are believed to require, when reading these claims on a combination of Takahashi et al. and Hikita et al., that the leading ends of electrodes 29 of Takahashi et al. must be compared with the leading ends of the additional electrodes to be added to Takahashi et al. When such a comparison is made, for reasons expressed previously, it is clear that the leading ends of the electrodes 29 of Takahashi et al. would be spaced further from a common surface than are the additional electrodes to be added. Thus, it is respectfully submitted that claims 35 and 41 were not properly rejected by the Examiner.

Regardless, new claims 57 and 59 include language which is believed to further require the Examiner to compare the leading ends of electrodes 29 of Takahashi et al. with the leading ends of additional electrodes to be added. In this regard, claims 57 and 59 recite

> leading ends of said pillared electrodes **joined to said at least one upper face electrode and said heat radiating plate** are substantially equally

spaced relative to one another from said surface of said heat radiating plate.

Similar language has been added to claim 35. This additional language of claims 35, 57 and 59 clearly establishes that when reading these claims on the prior art relied upon by the Examiner, a comparison between the leading ends of the electrodes 29 in Takahashi et al. and the leading ends of the additional electrodes added thereto must be made.

Thus, claims 57 and 59 are clearly not met by a combination of Takahashi et al. and Hikita et al., whereby claims 57-60 are allowable. Similarly, claim 35 is also clearly patentable in its own right.

In view of the above amendments and remarks, it is respectfully submitted that the present application is in condition for allowance and an early Notice of Allowance is earnestly solicited.

If after reviewing this Amendment, the Examiner believes that any issues remain which must be resolved before the application can be passed to issue, the Examiner is invited to contact the Applicants' undersigned representative by telephone to resolve such issues.

Respectfully submitted,

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wire is utilized to radiate heat, since the gold wire or aluminum wire used for wire bonding is limited in diameter, the wire should be used within a current capacity allowed for its diameter. A plurality of joints must be carried out for one electrode to cope with a large current as in a power source circuit. Although a distance between electrodes must be secured to ensure safety and reliability in accordance with a current increase, the distance is hard to secure in the case where the gold wire or aluminum wire is used because the wire is varied in shape at the time of wire bonding, deformed during subsequent processes, or the like.

SUMMARY OF THE INVENTION

[0011] An object of the present invention is accordingly to resolve the above issues and provide a semiconductor package which is comprised of one or a plurality of semiconductors and can exhibit a superior heat radiation effect, with the semiconductor package being of a simple structure and a stable quality. A method for forming the semiconductor package is also an object of the invention.

[0012] In order to accomplish the above objectives, the present invention is constituted as will be described below.

[0013] In accomplishing these and other aspects, according to a first aspect of the present invention, there is provided a semiconductor package comprising:

a first semiconductor having electrodes formed on both of an upper and a lower face;

a heat radiating plate to which a lower face electrode of the first semiconductor is joined with use of a joining member; and

pillared (columnar) or spherical electrodes ~~(i.e. projecting electrodes)~~ which are joined to upper face electrodes of the first semiconductor and the heat radiating plate, respectively.

[0014] According to a second aspect of the present invention, there is provided a semiconductor package according to the first aspect, further comprising a sealing resin with which the first semiconductor and a face of the heat radiating plate joined to the first semiconductor are covered in a manner to expose a part of leading ends of the pillared or spherical electrodes.

[0015] According to a third aspect of the present invention, there is provided a semiconductor package according to the first or second aspect, further comprising a second semiconductor having electrodes formed on both of an upper and a lower face, and being of the same kind as the first semiconductor. A lower face electrode of the second semiconductor is joined to the heat radiating plate with use of a joining member. The heat radiating plate has an electric circuit of an equal polarity formed of a single one of or a combination of gold, silver, copper, nickel, and tungsten and set to ceramic, with the first and second semiconductors being joined to the electric circuit of equal polarity.

[0016] According to a fourth aspect of the present invention, there is provided a semiconductor package according to the first or second aspect, further comprising a third semiconductor having electrodes formed on both of an upper and a lower face, and being of a different kind relative to the first semiconductor. A lower face electrode of the third semiconductor is joined to the heat radiating plate with use of a joining member. The heat radiating plate has an electric circuit of a plurality of independent polarities with the circuit being formed of a single one of or a

[0052] Fig. 13 is a plan view of the semiconductor package of the third embodiment of the present invention when electric circuits of equal polarities are formed on the entire surface of a ceramic radiating plate;

[0053] Fig. 14 is a sectional view showing a state of joining a circuit board and a semiconductor element with use of the semiconductor package of one example of the eighth embodiment of the present invention;

[0054] Fig. 15 is a sectional view of a state of joining a circuit board and a semiconductor element with use of the semiconductor package of another example the eighth embodiment of the present invention; and

[0055] Figs. 16, 17, and 18 are sectional views of semiconductor packages according to other examples of the eighth embodiment of the present invention.

Fig. 19 is a schematic cross-sectional view showing connection of a lower face electrode to a heat radiating plate via solder or conductive paste.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0056] Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

[0057] Semiconductor packages and methods for forming the semiconductor packages according to embodiments of the present invention will be discussed in detail below on the basis of drawings.

[0058] (FIRST EMBODIMENT)

[0059] Fig. 1 is a plan view of a semiconductor package according to a first embodiment of the present invention, and Fig. 2 is a sectional view of the semiconductor package.

[0060] In the semiconductor package according to the first embodiment of the present invention, a lower face electrode 50 of a semiconductor 1, having electrodes formed on both upper and lower faces, is joined to a heat radiating plate 10 with use of solder 51. Upper face electrodes 2 and 3 of the semiconductor 1, and the radiating plate 10, are joined to pillared (columnar) or spherical electrodes 11 ~~(i.e. projecting electrodes)~~.

[0061] The heat radiating plate 10 is formed of any one of copper, a copper alloy, aluminum, and an aluminum alloy. The metallic radiating plate 10 and the lower face electrode of the semiconductor 1 are joined to each other by solder. A thickness of a layer of the solder is made as small as possible, so that its heat conduction efficiency is improved. Other examples of a joining member are conductive paste, gold, or the like. When the joining member is solder, heat conductance, joining properties (ease of joining) of the semiconductor, and heat resistance may be improved. When the embodiment is applied to drivers of industrial motors such as AC servo motors, and there is caused any lock of rotation of the motor to generate heat of about 120°C to which the joining member is subjected, such a joining member is preferably formed of solder. When the joining member is of gold, heat conduction properties become high and electrical resistance becomes lower.

[0062] The pillared or spherical electrodes 11 formed of a metal essentially consisting of any one of gold, silver, copper, and aluminum are joined to the upper face electrode 2 (upper a electrode) and the upper face electrode 3 (upper b electrode) of the semiconductor 1, and are also joined to the metallic radiating plate 10 with use of ultrasonic oscillation, solder, or conductive paste. The conductive paste is a mixture of a metallic powder such as gold, silver, or the like and generally an epoxy

ABSTRACT OF THE DISCLOSURE

Electrodes of one face of a semiconductor, which has electrodes formed on both faces, and a heat radiating plate are directly joined to quickly absorb and diffuse heat of the semiconductor, thereby improving a heat radiation effect. At the same time, electrodes on an opposite face of the semiconductor are connected to pillared ~~projecting~~ electrodes that are thicker than a wire for wire bonding and larger in current capacity. These pillared ~~projecting~~ electrodes can accordingly be utilized as connecting terminals to a circuit board. Ceramic is used for the heat radiating plate, so that semiconductors of different functions can be mounted simultaneously.

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27. A semiconductor package comprising:

a first semiconductor having at least one upper face electrode on an upper face of said first semiconductor, and a lower face electrode on a lower face of said first semiconductor;

a heat radiating plate having a surface to which is joined said lower face electrode via [a joining member] solder or conductive paste, with said solder or conductive paste being in contact with said lower face electrode; and

[projecting] pillared electrodes joined to said at least one upper face electrode and said heat radiating plate, respectively, with leading ends of said [projecting] pillared electrodes being exposed so as to constitute electric connecting parts.

29. The semiconductor package according to claim [28] 27, further comprising a sealing resin covering said first semiconductor and said surface of said heat radiating plate, but not covering said leading ends of said [projecting] pillared electrodes.

30. The semiconductor package according to claim [28] 27, further comprising a second semiconductor having at least one upper face electrode on an upper face of said second semiconductor, and a lower face electrode on a lower face of said second semiconductor, with said second semiconductor being the same as said first semiconductor and with said lower face electrode of said second semiconductor being joined to said heat radiating plate via [a joining member] solder or conductive paste, and

wherein said heat radiating plate comprises ceramic and has an electric circuit of equal polarity formed from at least one of gold, silver, copper, nickel and tungsten, with said electric circuit being on said ceramic and with said first and second semiconductors being joined to said electric circuit.

31. The semiconductor package according to claim [28] 27, further comprising a second semiconductor having at least one upper face electrode on an upper face of said second semiconductor, and a lower face electrode on a lower face of said second semiconductor, with said second semiconductor [being] exhibiting different characteristics [from] relative to said first semiconductor and with said lower face electrode of said second semiconductor being joined to said heat radiating plate via [a joining member] solder or conductive paste, and

wherein said heat radiating plate comprises ceramic and has electric circuits of independent polarities formed from at least one of gold, silver, copper, nickel and tungsten, with said electric circuits being on said ceramic and with said first and second semiconductors being joined to said electric circuits, respectively.

32. The semiconductor package according to claim [28] 27, wherein

said heat radiating plate has a circuit for said first semiconductor and said [projecting] pillared electrodes, with said circuit being formed from at least one of gold, silver, copper, nickel and tungsten and being provided on a front surface of said heat radiating plate, and

said heat radiating plate comprises ceramic layers separated by a conductive layer that is of a material equal to a material of said [lower face electrode] circuit, with said conductive layer being connected to said circuit such that heat of said first semiconductor is to be radiated by said ceramic layers and said conductive layer.

33. The semiconductor package according to claim [28] 27, wherein said heat radiating plate comprises at least one of copper, a copper alloy, aluminum and an aluminum alloy, with or without being subjected to a surface treatment.

34. The semiconductor package according to claim [28] 27, wherein said leading ends of said [projecting] pillared electrodes are exposed by covering said [projecting] pillared electrodes with a sealing resin and then simultaneously removing a portion of said sealing resin and a portion of said [projecting] pillared electrodes.

35. The semiconductor package according to claim [28] 27, wherein said leading ends of said [projecting] pillared electrodes joined to said at least one upper face electrode and said heat radiating plate extend to a uniform height relative to one another by being smoothly pressed.

36. The semiconductor package according to claim [28] 27, wherein each of said [projecting] pillared electrodes comprises an inner portion and an outer portion, with said inner portion being of a hardness that is different than a hardness of said outer portion.

37. The semiconductor package according to claim [28] 27, wherein each of said [projecting] pillared electrodes comprises an inner portion and an outer portion, with said inner portion having a melting temperature that is different than a melting temperature of said outer portion.

38. The semiconductor package according to claim [28] 27, further comprising a second semiconductor having at least one upper face electrode on an upper face of said second semiconductor, and a lower face electrode on a lower face of said second semiconductor, with said second semiconductor [being] exhibiting different characteristics [from] relative to said first semiconductor, with said lower face electrode of said second semiconductor having current and voltage characteristics that are equal to current and voltage characteristics of said lower face electrode of said first semiconductor, and with said lower face electrode of said second semiconductor being joined to said heat radiating plate via [a joining member] solder or conductive paste as is said lower face electrode of said first semiconductor such that said first and second semiconductors are mounted on said heat radiating plate.

39. The semiconductor package according to claim [28] 27, wherein said heat radiating plate includes pits and projections on a surface that is opposite said surface to which said lower face electrode is joined.

40. The semiconductor package according to claim [28] 27, further comprising bumps between said at least one upper face electrode and one of said [projecting] pillared electrodes joined to said at least one upper face electrode.